Remarks

The various parts of the Office Action (and other matters, if any) are discussed below under appropriate headings.

Claim Rejections - 35 USC § 102 and § 103

I. Claims 1-5, 9, 19, 23, 24, 30 and 34-37 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,370,398 to Kanamaluru et al. ("Kanamaluru").

Specifically, the Examiner has taken the position that Kanamaluru discloses substantially all of the features of the claimed wave transformer and method and that "it would have been obvious to the skilled artisan that the phase shift claimed here results due to the quarter wavelength depth of the cavities in the metal twist plate 64" of Kanamaluru (Paper No. 12, pp. 2-3). It is respectfully submitted, however, that the Examiner's position is not supported by the teachings of Kanamaluru.

Kanamaluru discloses a compact antenna having a parabolic dome with a series of parallel metal wires arrayed on the inside surface of the dome. As a result, the metal wires filter the incident radiation such that only radiation with its electric field polarized orthogonal to the metal wires will pass through to the inside of the dome. Inside the dome, Kanamaluru provides a metal "twist plate" 64 that reflects the radiation back toward the dome. The twist plate has a plurality of parallel, evenly spaced grooves oriented to be offset from (not parallel to) the orientation of the wires in the dome. ***These grooves do not transform the shape of the incident wavefront.*** The grooves reflect the incident radiation and rotate its polarization so that its electric field is parallel to the orientation of the wires on the dome. With its rotated polarization, the radiation now reflects off the metal wires arrayed on the inside surface of the dome, and the parabolic surface reflects the radiation toward a focal point near the center of the twist plate.

Contrary to the position taken by the Examiner, the only "transformation" of the wavefront is performed by the metal wires on the inside surface of the dome. The shape of the reflected wavefront is determined by the shape of that surface. In this case, the parabolic surface focuses the radiation at the focal point near the center of the twist plate.

No teaching or suggestion has been found in Kanamaluru for selecting the position and dimensions of the grooves in the twist plate such that the energy reflected from that surface will be in phase at the focal point. The undersigned respectfully submits that a person of ordinary skill in the art would not be motivated to <u>select</u> the position or dimensions of these grooves to place the radiation in phase at a focal point, because Kanamaluru teaches using the inside surface of the dome, rather than the grooves, to shape the reflected wavefront so that the radiation will be in phase at the focal point.

Kanamaluru also clearly fails to address the problems that led to the present invention, such as the difficulty in forming a sufficiently smooth parabolic surface for use with millimeter-wave frequencies, for example (specification, p. 1, lines 8-16). Thus, it is further submitted that a person skilled in the art faced with this problem would not even consider Kanamaluru.

Withdrawal of the rejection is respectfully requested.

II. Claims 1, 6-8, 20-22 and 31 have been rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,429,823 to Baines et al. ("Baines").

The Examiner has taken the position that it would have been obvious to the skilled person in the art that the combined propagation phase shift and local phase shift from the plurality of feed horns (204) of Baines would place the electromagnetic energy

in phase at the focal point of Baines's reflector. However, no teaching or suggestion has been found in Baines for doing so.

Baines discloses a horn reflect array antenna for a satellite. The horn antenna has a plurality of feed horns, a dimension (depth) of which is selected to alter the phase of the reflected energy from each individual horn. This makes Baines's reflector easy to reconfigure remotely, such as on a satellite in space. While Baines does disclose changing the phase of the incident and reflected electromagnetic energy, that phase shift is provided as a means to alter the broadcast area, or spread, of the reflected energy. See Baines, FIG. 4.

No teaching or suggestion has been found for selecting the position of Baines's feed horns to provide a particular phase shift based on the combination of both a local and a propagation phase shift. Relying on a predetermined position of a cavity to effect the phase shift, however, would not provide the desired flexibility Baines intends. See Baines, col. 4, lines 57-67. Moreover, although position selection can be used to avoid reflected-wave grating lobes, Baines does not appear to have considered this problem. See the present application, p. 13, line 15 through p. 14, line 2.

This may be because Baines's feed horns are not cavities for a wavefront transformer. Baines's feed horns are more accurately described as variable delay lines. A feed horn is essentially an impedance transformer; it transforms the impedance of a transmission line (coaxial transmission line, waveguide, etc.) to a value close to that of free space, i.e., about 376 ohms. This impedance transformation is implemented via a gradual increase in cross-sectional area, as shown in Fig. 3 in Baines. In this way, nearly all the radiation incident on one side of the horn is transmitted to the other side. This is true in both transmit and receive modes.

As used by Baines, the horn antennas receive microwave power transmitted by a feed horn with minimal reflection from the aperture 210 of each horn. The received

power is transmitted down the throat of the horn to a region of smaller cross-sectional area where a movable short 216 or a phase shifter (or a combination of the two) is positioned to impose a desired phase shift on the received power, which is then retransmitted by the horn antenna, once again with minimal reflection by the aperture. The aperture 210 of each horn will typically be one or more wavelengths in diameter, endowing each horn with significant gain and thus a narrow transmitted beam, *minimizing* interference between neighboring horns.

For example, see Fig. 4 of Baines, which shows power contours at a frequency of 11.8 GHz over the continental U.S. The array used to generate these contours consists of 498 elements, each approximately three inches in diameter. At a frequency of 11.8 GHz, the diameter of the aperture of each horn is approximately three wavelengths, and the gain is approximately 20 dB. The absence of "crosstalk" between elements makes such an array easier to design than an array in which mutual coupling between elements must be accounted for.

The size of the aperture also limits the array's scope of performance, however. In receive mode, the array "samples" an incident wavefront, shifts the phase of the received sample, and then retransmits the result. The large size of each aperture limits the sampling rate. If each aperture is three wavelengths in diameter, then the corresponding rate at which the horn array samples the received wavefront can be no more than one sample every three wavelengths. Nyquist's theorem tells us that to adequately sample a signal requires at least two samples per period, or in the case of an array, two samples per wavelength. For a wavefront transformer to be capable of transforming a received wavefront into any desired transmitted wavefront requires a sufficiently-high spatial sampling rate of at least two samples per wavelength. The nature of the horn array of Baines makes this impossible. If the aperture of the horn is reduced to one-half wavelength or less, it ceases to be a horn antenna; that is, its gain drops dramatically, and its impedance-matching properties disappear. Thus the horn array of Baines must use independent non-interacting horn antennas.

By selecting the position of the cavities to account for the propagation phase shift and to avoid reflected-wave grating lobes, the present invention provides benefits not provided by Baines's horn antenna. Moreover, in the present invention it is the combination of the phase shifts from the plurality of cavities that places the reflected energy in phase at the focal point. The interaction between cavities makes this possible. Baines simply operates in a completely different manner.

Consequently, it is respectfully submitted that Baines fails to disclose an important element of the claimed invention, namely selecting the positions and dimensions of each of a plurality of cavities such that the combined phase shifts from these cavities cooperate to effect a desired phase shift at a focal point. Withdrawal of the rejection is respectfully requested.

Allowable Subject Matter

It is noted with appreciation that claims 10-18 and 25-29 have been allowed.

Conclusion

In view of the foregoing, request is made for timely issuance of a notice of allowance.

Respectfully submitted,

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